A question obtrudes itself as to what happens when s is an even integer. When $s = 2$, there is synchronism between the primary and a derived vibration, and the occurrence of the infinite denominator $4-s^2$ is what might have been expected. But in the case of other even integers no synchronism is apparent, and it would seem that the complication is of an analytical character only. The solution compounded of (102) and (103) changes its form. It would be of interest to follow out the process, say for the case $s=6$, which might roughly represent the circumstances of the Atlantic Ocean, but I am not prepared to undertake the task.

On a New Kind of Glow from Palladium in Vacuum Tubes.

By Rev. H. V. Gill, S.J., B.A., Downing College, Cambridge.

(Communicated by Prof. Sir J. J. Thomson, F.R.S. Received May 7,—Read May 13, 1909.)

(Plate 1.)

The phenomenon described in this paper was first noticed when making some preliminary experiments in an investigation suggested by Prof. Sir J. J. Thomson. The effect of the gases contained in metals on the nature of the discharge obtained when these metals are employed as electrodes in vacuum tubes has long been a question of interest. It was suggested that by employing palladium one might hope to obtain interesting results, owing to the property possessed by this metal of absorbing large quantities of hydrogen. The result of these preliminary experiments has already been briefly stated,* but as the effect seems to be a new one, it seemed of sufficient interest to call for a fuller investigation.

Apparatus.—A tube was fitted up containing an ebonite plug through which two stout brass leads were passed. To the extremities of the leads was attached, by means of screws, a piece of palladium foil about an inch in length and a tenth of an inch wide. The leads and plugs were fixed in position by sealing-wax. The tube was sealed by the blow-pipe to a mercury pump and was in connection with a pressure gauge, drying-bulb, etc. The tube could be isolated from the rest of the apparatus by means of a barometric mercury seal. By passing an electric current through the palladium, it could be heated to any required temperature. (See Plate 1, fig. 1.)

* 'Camb. Phil. Soc. Proc.,' vol. 14, No. 6, p. 578, 1908.

Appearance of the Glow.—The pressure was reduced to 0·15 mm., and a current was sent through the palladium with the object of expelling some of the gases which it might contain. It was kept at a dull red heat for some time, and was then raised to an almost white heat.

At this point a purple glow was noticed around the hot palladium.* This glow resembled the negative glow in a vacuum tube, but as there was no electric field except that due to the current from the two storage cells used to heat the metal, it seemed to require an explanation. The experiments described in this paper were made with the object of investigating the nature and cause of this luminosity. As the matter has not been hitherto studied, it seems useful to describe the results of these experiments with greater detail than would otherwise be desirable.

The most satisfactory form of tube was that shown in the figure, in which the general appearance of the phenomenon is indicated. The colour of the glow is a rich purple-blue; when the foil is very hot, it appears bluer, but this is due to the light reflected from the walls of the tube. There is a "dark space" between the glow and the palladium, which is well marked when the foil is at a high temperature. The luminosity does not extend to the walls of the tube, especially when this is 4 or 5 inches in diameter. Its general appearance is like a purple halo around the hot palladium. The glow disappears when the current is stopped and begins again when it is sent through once more.

Material employed.—The palladium foil used on the first occasion was a piece that had been in the laboratory for some time, and had all the appearance of having been heated up on former occasions. Some fresh palladium was obtained, and this, too, produced the glow. As palladium melts at a comparatively low temperature, it was found advantageous to use platinum foil into which some palladium black had been well rubbed instead. This gives almost as good results as the palladium foil, and has the additional advantage that there is a less dense deposit of disintegrated palladium on the walls of the tube. Experiments will be described showing the part played by the disintegration of the metal. In order to be assured that the phenomenon was due to the palladium itself and not to any dirt which might be on it, a piece was carefully cleaned as follows. It was heated for a few moments in strong nitric acid, which dissolved a thin layer. It was then washed and put into chromic acid, after which it was washed again. Finally, when it had been attached to the leads, it was once more put into chromic acid, washed in distilled water, and rapidly dried by pure alcohol. This piece of palladium produced the glow even better than other pieces which

* See figures on plate.

had not been carefully cleaned. Other substances, such as platinum and carbon filament, were also tried, but the glow was not obtained.

Electric Field.—It appeared possible that the phenomenon might be directly connected with the well-known ionisation effects produced in the neighbourhood of hot metals. The glowing palladium was connected with the terminal of a battery of small cells, the other terminal being attached to an electrode in the glass tube at a distance of about an inch from the palladium. Various potentials up to 400 volts were applied without any effect on the glow; nor did it make any difference whether the palladium was attached to the positive or negative pole of the battery. Even the passage of a luminous discharge did not influence the general appearance of the glow.

Magnetic Field.—The application of a magnetic field was also found to be without effect.

Effect of Heat.—In the original experiment it was noticed that the glow soon faded away. This happened in a narrow tube, which at the same time became very hot.

It was subsequently found that the disappearance of the glow was caused by the heat of the walls of the tube. If the tube is kept cool by placing the bulb in cold water, it is possible to keep the glow going indefinitely. The effect of the temperature of the walls of the tube is not the least strange feature of the phenomenon. If the tube be heated by means of a bunsen burner the glow fades away, and only returns when the tube has become cool again. If one side of the tube be heated and the other kept cool, it is found that the luminosity disappears on the hot side, but remains on the cooler one.

The Dark Space.—The dark space surrounding the palladium seems to be due to the temperature. A second pair of leads was introduced into the tube, to which was attached a small spiral of platinum wire. When this was placed well in the glow, which had been produced in the usual way, it was found that, if the spiral was heated to a high temperature, a dark space was produced around it. This shows that the dark space around the palladium is due to its temperature. This dark space is not a contrast effect, as it can be seen when an opaque object is held over the hot metal. So, too, the heating of the gas in the tube, the leads and walls, tends to diminish the intensity of the glow. If the current be stopped for a short time so as to allow everything to grow cooler, it is found that the glow is brighter on re-heating the palladium.

Initial Pressure of the Gas.—The phenomenon occurs within wide limits of initial pressure. It was observed within a range of pressures from 0·2 to 0·003 mm. Generally the pressure goes up when the palladium is heated.

This rise of pressure depends on the condition of the palladium. On one occasion, when the pressure was rising owing to a slight leak in the sealing-wax, the glow was still visible when the pressure has gone up a centimetre or more. The rise in pressure in normal cases is of the order of a millimetre.

Action of Gases in the Tube.—The fact that the glow could be obtained when the initial pressure of the tube was very low, so that the bulb gave green fluorescence when a discharge was sent through it before heating the foil, seems to show that the glow depends on the presence of gases which have come from the hot palladium. When the tube had been filled with hydrogen before being exhausted, it was found impossible to produce the glow in the ordinary way. When, however, the palladium was made the cathode of a coil discharge through the tube, it was observed that the glow suddenly appeared. When the luminosity had once been produced, the cold discharge had no further effect. In general, when the glow was slow in appearing, it was found that it was helped by passing a discharge through the tube for a short time. The following experiment proves that the presence of gases in the tube which have been produced from the palladium is necessary. The glow was obtained in the usual way and allowed to continue for some time. Air was now admitted to the tube and the tube was again exhausted to a pressure favourable for the phenomenon. The palladium was again heated up, but the glow was not obtained. In the same way, it was found that a piece of palladium which had been recently heated would not give the glow. Another similar result was obtained by attaching a side tube containing charcoal to the glow-bulb; when this was placed in liquid air, the glow disappeared, and returned again when the liquid air had been removed.

Palladium recently heated.—Various methods were tried to restore to palladium which had been heated for some time the power of producing the glow, without success. It was saturated with hydrogen gas, and was made the electrode in a vacuum tube discharge, and was placed near the cathode in such a discharge, but the power of producing the glow was not restored. The only method found successful was to leave the palladium exposed to the air for a considerable time. Thus after six weeks the property of producing the glow was found to be restored to a moderate degree.

Disintegration.—The disintegration of the palladium has an important connection with the luminosity. Either the particles of palladium are themselves the cause of the luminosity or they carry with them something which acts on the gases in the tube. The black deposit on the sides of the tubes is soluble in cold nitric acid, and can be easily rubbed off the glass. The following experiment shows the importance of the disintegration of the

palladium. A tube was fitted up with two pairs of leads; to the extremities of one pair was attached a piece of palladium foil, and to the other a piece of platinum foil. A piece of glass tubing was placed over the extremities of the leads carrying the platinum foil. The tube extended about an inch on each side of the platinum, thus shielding it from the deposit from the palladium. The latter was now heated and the glow obtained. This was allowed to continue for some time. The current through the palladium was stopped, and the glass tubing removed from over the platinum by inclining the tube. The platinum foil was then heated by a current of electricity. No glow was obtained. This result is important, as it shows that the glow is not due merely to the heat from incandescent metals. The platinum foil was then allowed to cool, and the palladium heated again. The glow appeared in due course. As the platinum foil was now exposed to the disintegration of the palladium it was blackened by a deposit. The current was stopped through the palladium, and the platinum was heated. This time, when the platinum was raised to a sufficiently high temperature, the glow appeared, and was almost as bright as in the case of the palladium. This result, taken with those just described, proves that the luminosity is due to some reaction between the disintegrated palladium and gases in the tube. It was observed that a small piece of mica placed near the palladium had the effect of preventing the glow in its shadow. Behind a small opaque screen the glow was seen slightly.

Mercury Vapour.—The experiments already described prove that the luminosity depends on the gases in the tube. In order to see if mercury vapour had any part in the phenomenon an experiment was made in which this was carefully excluded. A glass spiral was carefully cleaned with nitric acid, and was then placed in a vessel of liquid air; one extremity was now sealed to the mercury pump and the other to a tube which had been fitted with fresh leads and which had been carefully cleaned away from mercury vapour. The bulb was now exhausted to the required pressure, and was then sealed off from the pump. As the spiral had been in the air during the whole operation, any mercury vapour that came from the pump was frozen out before it could reach the tube. That there was no mercury vapour present in the tube was shown by the absence of mercury lines in a discharge between the leads and an electrode which had been placed in the side tube of the bulb. When the palladium was heated the glow came in the ordinary way. Thus the presence of mercury vapour is not an essential condition.

Phosphorus Vapour.—A similar experiment was made to see if the phenomenon had anything to do with any impurity arising from the

phosphorus pentoxide employed in the drying tube. Crookes* showed that the presence of some such impurity accounted for the blue face often seen on striæ in vacuum tubes. This time the tube was first exhausted as far as possible by means of a water pump and then brought to the right pressure by means of a charcoal bulb in liquid air. The pressure could be judged by the thickness of the dark space of a discharge through the tube. In this experiment care had been taken to use nothing which had been exposed to phosphorus pentoxide or other known source of phosphorus vapour. In this case also the glow was obtained as before.

Water Vapour.—The influence of water vapour was shown by the following results. A small side tube was inserted into the bulb of the tube in which the glow was obtained. This was so placed that its extremity reached into the purple glow. This tube was like a test tube with the open end outside. The palladium was heated and the glow produced. A few drops of liquid air were now introduced into the side tube. After a few seconds the glow began to fade away and finally disappeared. At the same time a white deposit appeared on the extremity of the side tube. When the liquid air had boiled off and the side tube had regained its ordinary temperature the glow gradually returned.

In this way the glow could be made to go and come as often as was desired. The same result could be obtained by allowing a few drops of liquid air to fall on the surface of the bulb. This seemed to show that the glow depended on the presence of water vapour. In order to ascertain that the absence of the glow was due to this cause a tube was fitted up in the usual way containing some phosphorus pentoxide. When the tube had been left long enough to enable the water vapour to be absorbed it was found that the glow could not be obtained. Thus the presence of water vapour is a necessary condition for the appearance of the glow. This was also evident from other indications. If the tube was very carefully dried the glow was not so easily obtained as when less care had been taken. The best results were obtained when the apparatus had been filled with air which had not passed through a drying tube. The result shows that the effect of the liquid air is to freeze out the water vapour from the bulb. The results already obtained by heating the bulb may also be connected with the effect of heat on the water vapour in the tube. This point will be considered when dealing with the probable cause of the phenomenon. It might be thought that the precautions already described to keep out mercury would also abstract water vapour from the bulb. The spiral in liquid air was some distance from the bulb, and the whole operation of exhausting it only

* 'Roy. Soc. Proc.,' vol. 69, p. 399, 1901.

occupied a short time. As will be shown further on, water vapour is also produced when the metal in the bulb is heated.

Spectrum of the Glow.—The examination of the spectrum of the glow is rendered difficult owing to the amount of light reflected from the walls of the tube. In spite of all precautions taken to do away with this inconvenience there was always a considerable quantity of reflected light when the glow was sufficiently bright to make satisfactory observations. It was found, however, possible to obtain some interesting information by examining the spectrum. When the spectrum is viewed through a spectrometer of low dispersion, the spectrum consists of a continuous portion extending from the red towards the blue end. Just at the extremity of this region there is a blue-green band. This band can only be observed when the glow is very bright and the dispersion of the spectrometer low. Then there comes a dark space, which at first was thought to be an absorption band, and then a blue band. When the spectrum of the reflected light was observed in the absence of the glow it was found that the two bright bands were absent, and that the continuous portion only extended to the beginning of the dark space. When the glow was present these bright bands were present as an addition to the spectrum of the reflected light. No doubt other lines or bands could have been seen but for the presence of the reflected light. Indeed, the green-blue band could not be seen as a rule, but was sufficiently well marked when the glow was very bright. This spectrum was then examined with a direct reading Hilgar spectrometer. This instrument gave considerably greater dispersion than the other, and the band was therefore less well marked. It was possible, however, by remaining in the dark for some time to distinguish the blue band sufficiently well to measure it. It was not possible to measure the green band directly. It was identified indirectly. As the edges of the blue band are not well defined it was only possible to take approximate readings of its limits. Various sets of readings taken after intervals of some considerable time gave readings for the middle of the blue band which agreed very substantially. The spectrometer had previously been standardised by being set at the blue mercury line, which is very close to the position of the blue band.

The following are the wave-lengths of the various parts of the spectrum:—

Beginning of the continuous spectrum	6220
Beginning of dark region	4697
Beginning of the blue band from glow	4419
Reading taken as middle of the blue band	4380
End of blue band	4343

It was not possible to determine whether this blue band was composed of narrower bands or lines.* It had all the appearance of a broad band.

This band did not appear to correspond to any portion of the spectra involved in any of the substances one expected to meet with in the experiment. It was thought that the examination of the spectrum of the gases in the tube made in the ordinary way might throw some light on the matter. For this purpose a small spectrum tube was attached to the tube connecting the pump and the glow tube. The whole was exhausted as usual and the glow obtained. The spectrum tube was now sealed off from the rest and thus a specimen of the gas in the bulb was obtained. This was connected to an induction coil and its spectrum examined. The hydrogen lines were of course prominent. In addition the spectrum of carbon monoxide was very strongly marked. All who have worked with hot metal cathodes have remarked the amount of carbon monoxide produced in the tube. At least the spectrum of carbon monoxide is always present. A blue portion of this spectrum was found to correspond exactly with the blue band due to the glow. The spectrum tube was placed on the far side of the bulb, so that it could be examined with the spectrometer through the latter. The glow was then produced and at the same time a discharge was passed through the spectrum tube. By this means it was ascertained that the bands in the spectrum of the glow corresponded to two bands in the spectrum of the gas in the vacuum tube. The darker region in the spectrum of the glow also corresponded with a less luminous part of the spectrum of the gas in the discharge tube.

The end of the continuous spectrum due to the reflected light just corresponds to the green-blue band. The spectrum of the gas in the discharge tube was that of carbon monoxide. We have therefore sufficient evidence that the spectrum of the glow is due to carbon monoxide gas. No doubt, were it not for the reflected light it would be possible to find other bands and lines of the spectrum due to that substance. The blue band which was measured corresponds to a region of lines and bands close together. The other band corresponds to that of the carbon monoxide spectrum 4836.

The spectrum of carbon monoxide burning in air is a continuous one as far as can be seen. This spectrum includes the bands of the spectrum of the glow, but does not show the dark region, and also extends further towards the blue end.

Polarisation absent.—It seemed just possible that the glow might be due to light scattered by particles of matter in the tube. To test this view the

* See note at end.

glow was examined by means of Nicol's prisms to detect any sign of polarisation, but with negative result. A strong beam of light from an arc lamp was also passed through the glow, for if the colour was due to reflected light this ought to make a difference, but no such difference could be observed. It seems justifiable to conclude that the luminosity is from the materials in the tube themselves, and from the spectroscopic results it seems that this luminosity is connected with the presence of carbon monoxide gas.

Theoretical.—In putting forward any theory as to the cause of the phenomenon it is necessary to take into consideration the properties of palladium. A brief enumeration of the properties which seem to have a connection with this effect will be of assistance in arriving at some conclusion. It is well to bear in mind that the electrical properties of hot metals are still known but very imperfectly, and any theory about the precise mechanism of the reactions taking place near hot wires will naturally depend much on our knowledge of such properties.

The chemical behaviour of palladium is of a very peculiar and complicated character. Various researches have been made on its properties of combining with hydrogen and other gases, to some of which it will be necessary to briefly refer. That the phenomenon depends on these properties is evident, though the reaction which appears to be the one here involved is not that which would at first suggest itself.

An analysis of palladium black was made by Mond, Ramsay, and Shields,* in which they showed that this material in its natural condition contains 1·6 per cent. by weight or 138 vols. of oxygen in the form of PdO. It also contains 0·72 per cent. of water. Palladium goes on absorbing oxygen up to a dull red heat, and can absorb as much as 1000 vols. When exposed to hydrogen gas some of this oxygen unites with the latter to form water. Of the 873 vols. of hydrogen which palladium can occlude, 92 per cent. can be pumped off at ordinary atmospheric temperature, and nearly all the remainder came off at about 450° C. No doubt palladium, like platinum, will keep giving off hydrogen for a very long time even when heated to a high temperature. The most favourable temperature for the absorption of hydrogen at atmospheric pressure is 100° C. At this temperature it parts with nearly all its hydrogen *in vacuo*. These latter numbers appear to be also true of other forms of palladium.

It is a well-known fact that hydrogen which has been occluded by palladium and then driven out is much more active than ordinary hydrogen.

Many peculiarities in the behaviour of palladium have been noticed which

* "On the Occlusion of Hydrogen and Oxygen by Palladium," 'Roy. Soc. Proc.,' vol. 62, p. 290.

tend to complicate the study of its properties. There is one other reaction which is of the greatest importance in connection with the phenomenon under consideration, though it is one which did not seem to have any connection with the glow at first. It is found* that palladium charged with hydrogen has the property of causing the combination of oxygen and carbon monoxide in the presence of water to form carbon dioxide. This would appear to be the reaction involved in the production of the luminosity, and it can be shown that the facts already stated in this paper can be reasonably interpreted on this view. The series of reactions involved may very well be somewhat as follows.

When the palladium is first heated the glow does not make its appearance until some little time has elapsed. During this time the hot metal would be giving off hydrogen and oxygen, and water vapour, or would be bringing about the union of some of the gases to form water. Also carbon monoxide would be being produced in the tube. The help given by the passage of an electric current would probably consist in the formation of carbon monoxide or water vapour in the tube. The advent of these gases in the tube gives rise to an increase of pressure. Whatever be the origin of the carbon monoxide, its presence, as indicated by its spectrum, is always noticed in the discharge from a hot cathode. At the same time the palladium is disintegrating, the higher the temperature to which it is raised the greater being the disintegration. As we have seen, at the high temperature of the hot palladium the gases have been expelled, and thus the particles of metals are not charged with hydrogen when they leave the piece of foil. As these particles of metal travel out their temperature falls, and they may then absorb hydrogen. They are now in a condition to act on the oxygen and carbon monoxide and water vapour in the tube. If we suppose the union of the oxygen and carbon dioxide to take place with luminosity, we have all the facts about the glow accounted for. What the nature of this union is cannot be discussed here. That all such cases of combination are closely connected with electricity seems certain; and that the electrical properties of hot metals enter into this reaction would seem most probable. However, too little is known as yet concerning the phenomena connected with hot metals to justify a discussion on this point.

The explanation just suggested seems to account for the facts which have been ascertained about the glow. According to this view, it is clear that a piece of palladium which has been strongly heated not long before could not produce the glow. Its recovery by exposure to the air is also accounted for. The presence of water vapour as a necessary condition

* Traube, 'Ber.,' vol. 15, pp. 2325, 2854; Remsen and Keisen, 'Ber.,' vol. 17, p. 83.

follows. So, too, the presence of carbon monoxide is explained. The peculiar effect of heat might, perhaps, be as follows. Near the hot metal, as has been said, the particles of palladium are not charged with hydrogen, and hence not in a condition to bring about the union of oxygen and carbon monoxide. So, too, the effect of strongly heating the tube might be accounted for. Heating the tube may also have the effect of expelling hydrogen from the disintegrated palladium deposited on the sides of the tube, since an excess of hydrogen interferes with the reaction just described.

Whether this luminosity is directly connected with the ionisation of gases by incandescent metals is a point which has not been investigated. The writer hopes to make some experiments with a view to ascertaining if any special electrical effects can be detected in connection with this glow. The general laws concerning the electrical phenomena due to incandescent metals has already received a good deal of attention, but much remains still to be cleared up. Many of the facts described in this paper suggest some connection with the phenomenon of ionisation, and it seems very probable that the presence of the ions from the hot palladium in the gas may be an important factor in the reactions which give rise to the luminosity. Richardson* found that a wire which had lost the power of giving a positive leak owing to having been heated in incandescence can be made to regain it by being made a cathode in an electric discharge through gas at a low pressure, or by being placed near a cathode. This fact is recalled by the influence of the hot palladium on a piece of platinum placed near it, which we have described. In the latter case the phenomenon appears to be either entirely due to the deposit of particles of the disintegrated metal or to be connected with such a deposit. The recovery of palladium owing to its exposure to air has also its counterpart in the case of the recovery of the power of ionisation. In connection with these phenomena, a result may be mentioned here which is of interest, though no direct connection with the nature or cause of the glow has been found.

Another Effect.—An experiment was made in which the piece of palladium foil mounted to the leads was made the cathode of an electric discharge. The palladium was cold during the discharge. When the discharge was stopped the current was sent through the foil. Before the foil got red hot a slight blue-white luminosity was seen at its surface for an instant. On stopping the current and turning it on a second time this did not appear. The current was now regulated so that it was able to heat the foil just up to a red heat, but not strong enough to make it visible even in a very dark room. This current was stopped and a discharge from the coil sent through

* *Cf.* Richardson, 'Phil. Mag.,' (6), vol. 8, 1904, and (6), vol. 9, 1905.

the tube for a minute or two. When this was stopped the wire was heated and at once the luminosity was seen. This only lasted a few seconds, and did not reappear when the wire was heated a second time. The phenomenon could be reproduced by again sending the discharge. This result has evidently a connection with the phenomenon of thermo-luminescence, but the two do not seem to be identical. The latter phenomenon is only known in connection with bodies called by Van't Hoff "solids and solutions,"* which are obtained by precipitating simultaneously two salts from a solution in which one is greatly in excess of the other. Here there does not appear to be any salt in question, though it is possible that the effect is analogous and is due to the presence of impurities in the metal. A piece of platinum foil which had been carefully cleaned in nitric acid did not produce this result. On the other hand, it was observed when a "lime cathode" was used. It is not necessary that the palladium should be itself the cathode. The effect was also observed when it was in the luminous discharge from other electrodes. Even when the palladium was itself the cathode the effect was not noticed except when the luminous discharge was about it. The result was noticed also when the palladium was anode, but the coil discharge was not unidirectional although there was a spark gap in the circuit. This effect has not yet been examined in any detail, and the subject is only introduced as being connected with palladium.

It has been assumed that carbon monoxide gas is present in the tube: in any case its presence is indicated by its spectrum. The spectrum of carbon monoxide is always shown when carbon dioxide is introduced into the tube, and it appears to be due to the fact that the carbon dioxide is decomposed into oxygen and carbon monoxide, which then recombine again to form carbon dioxide.

This research was carried out in the Cavendish Laboratory, and the writer is very grateful to Prof. Thomson for his many helpful suggestions and encouragement.

[*Note added May* 30.—Since this paper was read it has been possible, through the kindness of Mr. J. E. Purvis, St. John's College, to obtain a photograph of the spectrum of the glow. The photographic record shows only one band, the position of which agrees with the measurements given in the paper. A photograph of the spectrum of a CO tube taken on the same plate shows that the blue band which constitutes the spectrum of the glow corresponds to the 4380 band of the spectrum of carbon monoxide. When

* Van't Hoff, 'Zeit. f. Physik. Chem.,' p. 322, 1895; E. Wiedemann and Schmidt, 'Wied. Ann.,' vol. 54, p. 604, 1895.

the negative is examined with a magnifying glass it is possible to distinguish several bright lines in the band which correspond to lines in the carbon monoxide spectrum. With an exposure of nearly half an hour no record was obtained of the other band referred to in the text. The single blue band seemed to constitute the spectrum under ordinary circumstances. It may be possible to obtain further evidence by using extremely sensitive plates and longer exposure. The photograph of the glow spectrum is not sufficiently distinct for reproduction, though quite clear enough for comparison with other photographs.]

DESCRIPTION OF PLATE.

FIG. 1.—Sketch of tube employed to show the glow.

FIG. 2.—Shows general appearance of the glow. The central white area is due to the glare of the hot palladium. Owing to halation the outline of the piece of foil cannot be distinguished. Around this is the "dark space." This is only relatively dark. All round is a hollow shell of luminosity, so that the photograph is taken through this. Then comes the glow proper, which gradually reaches a maximum and fades away again. The outline of the bulb is just visible below the glow.

FIG. 3.—Shows the glow with an opaque object in front of it to remove halation effects. The dark space can be seen.

FIG. 4.—Was taken with a larger aperture when the glow was more diffuse, and with a longer exposure. The temperature of the palladium was lower than in the other cases, and the dark space is not seen.

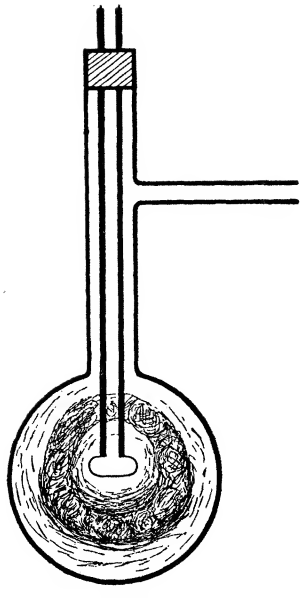

FIG. 1.

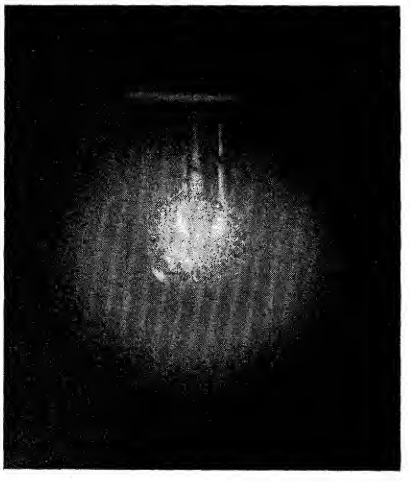

FIG. 2.

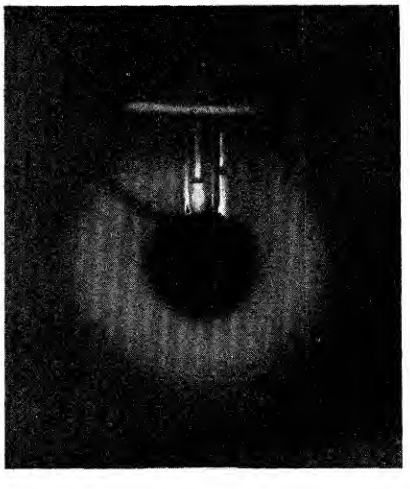

FIG. 3.

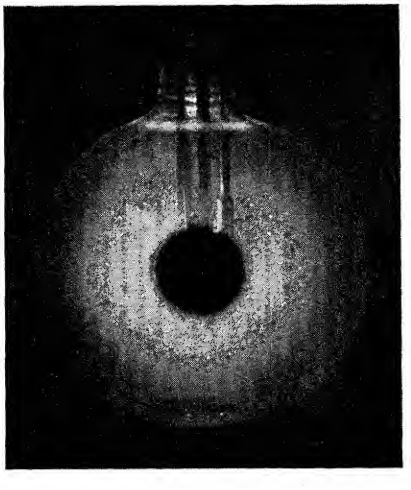

FIG. 4.

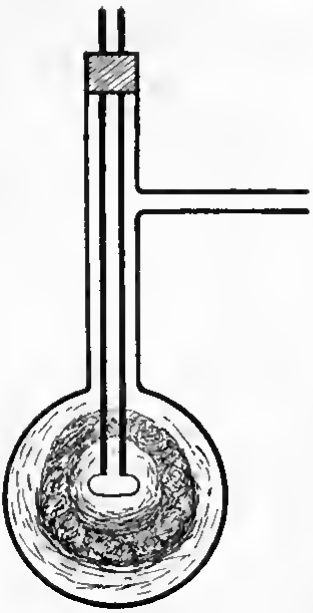

FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

DESCRIPTION OF PLATE.

FIG. 1.—Sketch of tube employed to show the glow.

FIG. 2.—Shows general appearance of the glow. The central white area is due to the glare of the hot palladium. Owing to halation the outline of the piece of foil cannot be distinguished. Around this is the "dark space." This is only relatively dark. All round is a hollow shell of luminosity, so that the photograph is taken through this. Then comes the glow proper, which gradually reaches a maximum and fades away again. The outline of the bulb is just visible below the glow.

FIG. 3.—Shows the glow with an opaque object in front of it to remove halation effects. The dark space can be seen.

FIG. 4.—Was taken with a larger aperture when the glow was more diffuse, and with a longer exposure. The temperature of the palladium was lower than in the other cases, and the dark space is not seen.